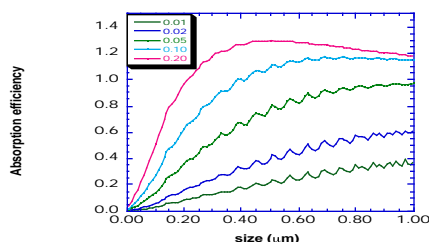


## Modeling of Laser-Induced Damage in NIF UV Optics

Reducing laser-induced damage to UV optics in the National Ignition Facility's (NIF's) final optics assembly is important for reducing operational costs. Full NIF performance corresponds to 8 J/cm<sup>2</sup> of average fluence at 3-nm pulse lengths and at 351 nm in the optics downstream from the conversion crystals. Recent experimental and theoretical progress has led to reductions in the number of surface-damage initiators and in understanding the evolution of damaged-area growth upon multiple laser-pulse irradiation. Work is continuing to identify and eliminate surface-damage initiators that are operative in the 8–14 J/cm<sup>2</sup> fluence range. Since it is unlikely that all initiators can be removed, especially under operational conditions, it remains important to understand how damaged areas grow upon repeated irradiation and to determine the factors that most influence growth. LS&T has contributed to a broad modeling effort to investigate physical mechanisms underlying observed damage behavior and to aid in the design and interpretation of experiments.

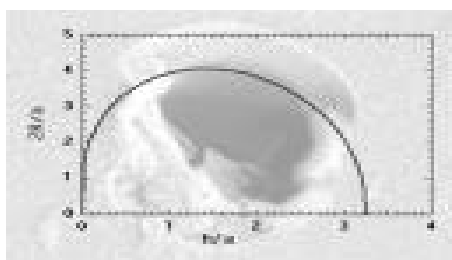
Initial laser damage in nominally transparent materials can be due to extrinsic factors like absorbing contaminants. We are investigating the energy absorption by such contaminants and the resultant damage craters in order to help identify initiators. Typical initiation craters range in size from a few microns to a few tens of microns in size.

The role played by microcracks created by surface finishing is of particular interest for damage growth. Two ways such cracks can be important are through local electric field intensification due to total internal reflection and through trapping light-absorbing contaminants. Cracks can also exhibit absorbing electronic surface states that can be potential initiators.



We performed a series of Mie scattering calculations to determine the absorbed fraction of laser energy incident on the geometric cross section of small absorbing particles in silica. The curves in the figure in the first column were generated for various values of the imaginary part of refractive indexes. This fraction can be larger than 100% due to diffraction. The strongest absorption shown corresponds to ceria contaminants corresponding to an imaginary refractive index value of 0.2.

The theoretical curve shown below describes the relationship between crater diameter  $2R$  and depth  $h$  beneath the surface of absorber of radius  $a$ . Our observed initiation craters correspond



to the shallow end of this curve implying that the defects are near the surface.

We have also begun simulations of field intensification in the vicinity of typical crack networks and evaluation of its importance for both damage initiation and subsequent growth. Absorption and intensification simulations together with detailed numerical simulations of crater formation will enable development of a comprehensive model of laser damage including both damage initiation and growth.

(Mike Feit)

## 4th Harmonic Laser Trigger System for the Z Accelerator

Under sponsorship of Sandia National Laboratories, we have designed, built, and tested a Nd<sup>3+</sup> laser that produces near diffraction-limited, high-energy laser pulses at the 4th harmonically converted wavelength of 263 nm. The objective of this laser system is to initiate breakdown in Z accelerator's high-voltage switches. The switches deliver currents of several megamperes to dense electric discharges, called z pinches, which generate

intense x rays used to drive inertial confinement fusion (ICF) and other high energy density physics experiment for DOE's Stockpile Stewardship Program.

The solid-state laser we have built offers several advantages relative to the 248-nm KrF excimer laser currently used to trigger the Z accelerator's high-voltage switches. Chief among these is superior beam quality and shorter pulse rise time (several hundred ps), properties expected to reduce switch timing jitter and improve synchronization of the Z accelerator with its diagnostic x-ray backlighter pulse. The backlighter pulse will be generated by Z/Beamlet, a 2-kJ, 526-nm laser now being constructed by a joint LLNL–Sandia team. Such backlighter pulses generate point sources of x rays for generating time-resolved radiographs of imploding ICF targets on other target packages. Backlighter beams have been used in other ICF facilities.

The trigger laser, shown below, effectively generates pulses at 1,053 nm using an injection-seeded Nd:YLF regenerative amplifier and a 4-pass 1-cm Nd:glass rod amplifier. A phase conjugator is used to maintain 2–3 times diffraction-limited wavefront quality. The 10-ns output from the four-pass amplifier feeds three separate channels, each with a single-pass 1-cm rod amplifier and a pair of BBO crystals for frequency conversion to the fourth harmonic. We have recently completed testing on one of these channels and obtained ~850 mJ at 263 nm with 3.6-J incident radiation at 1,053 nm. A harmonic conversion efficiency of >25% was achieved as limited by two-photon absorption at 263 nm. The laser is slated to be activated at Sandia's Z accelerator in Albuquerque, NM, in 2001.

(A. Erlandson)

